Multi Medical Data Visualizations for Maintaining Wireless Body Networks (WBNs) Capability

Elyas Palantei[1,1], Amil Ahmad Ilham[1], Syahril Syam[1], Sri Wahyuni[1], Arifuddin Tiro Parawangsa[1], and Hasradin[1]

[1] Department of Electrical Engineering, Faculty of Engineering, Universitas Hasanuddin, Jl. Perintis Kemerdekaan Km. 10, Tamalanrea, Makassar, Indonesia
{elyas_palantei, amil}@unhas.ac.id, and
{yuni.maliek, arifuddin.tp, hasradin.unhas}@gmail.com

Abstract. The current progress on the study of wireless body networks (WBNs) has gained tremendous achievements to be applied in various modern e-Health technologies. The manuscript examines a typical WBN configuration incorporated with the corresponding multi-medical data visualization window to maintain the patient medical data recording. Several numbers of the basic time-series data visualization approaches are adopted. The WBN was constructed to operate at 2.4 GHz ISM unlicensed band. The utilization of the designed WBN allows the physician or authorized health officers to perform routine health checks, anytime and anywhere, to a patient who is in the intensive health care status. The e-Health monitoring network is very suitable to place in the ICU/emergency rooms or it can be used by patients who are under regular treatment from a remote location. One unit WBN can be connected to the multi medical sensors of the different functions such as an ECG sensor to measure heart rate; a pulse sensor to measure the blood pressure; a temperature LM35DZ sensor to collect the human body temperature; a respiration sensor to measure the patient's breath and a video camera to observe the patient physical condition. An extensive evaluation of the designed WBN will be discussed more detailed later.

Keywords: WBN, medical data visualization, e-Health, medical electronic sensors, and telemedicine.

1 Introduction

The application of wireless communication technology in healthcare, which is commonly known as telemedicine, has gained a great popularity to be widely used in the modern society [1-11]. Exploitation of wireless technology allows the creation of a health care system that is more practical, effective, and efficient. Through this way,

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the medical personnel can monitor the health situation of patients from a different place at the same time.

The research and development on the use of wireless sensor network system for monitoring human health continues to grow [1-9]. Earlier study that produces wireless sensor network applications for monitoring the patient heart pressure rate has been implemented using a single sensor connected through an XBee-Pro transceiver chip as a data transfer medium between an human WBN (wireless body network) systems and a computer acted as a signal receiver and medical chart display [3]. Assessment activities of this system exhibited that the communication distance provided has a limited distance range about 200 meters. Thus, the remote monitoring instrument will be hard to perform thoroughly over this distance. It resulted in the use of health vital signs monitoring facing the technical difficulties, in terms of the low power received and increasing of the packet loss, over the maximum distance separation between the data collecting unit and the end transceiver part.

The utilization of web-service-based technology enables the creation of a health care system more practical, effective, and efficient example of medical personnel to perform the monitoring activity of the vital signs of the patient's health without the need for direct interaction in the same room so that the problem of shortage of medical personnel and the limited capacity of the hospital will be minimized. The use of web services technology through a variety of web-based application is able to bring a software infrastructure system that can present information in a rapid, precise, accurate, dynamic, and flexible with a high level of security in response to the need of the better, reliable, and optimal of the health services.

Based on the facts and the needs of society as well as the description above, it is clear that further research is needed to develop a medical information system with orientation on human health monitoring systems that display medical data from various sensors (multisensor). One model that can be developed multisensor monitoring namely that uses the internet to reach a farther distance communication can be built and integrated through application and web -based user interface. Development system is intended to address the needs of human health monitoring of various different vital signs of human health such as heart rate, body temperature, blood pressure, and so on. simultaneously in the same time so the whole health monitoring of patients can be done effectively and efficiently. The use of the Internet as a medium for delivery of sensor data to a web server to make patient health monitoring can be performed by medical personnel, anytime and anywhere, without limited by distance and time for communication network connections are through a specific provider. Besides this medical information system will also organize data from various sensors (multisensor) different to the database dynamic and flexible so that patient health data will be stored neatly and safely and at times can be used as a reference for the patient's medical record ongoing medical treatment.

Various advanced research activities regarding the WBN system to be applied for the human health monitoring system using more than one electronic sensor (multi-sensors), wirelessly, continue to experience significant improvements. Research on health monitoring system using wireless multisensor is mainly focused to address the needs of human health monitoring activity to collect various health parameters such as cardiac data, the body temperature, and the blood pressure, simultaneously and real-timely. In addition, the health monitoring system in this study will also organize

data from a variety of different sensors into a data base so that the recorded patient health data will be stored securely and can be used for ongoing medical treatment at any time.

2 Wireless Body Network (WBN) Architecture

A varieties of the WBN systems deploying a multiple sensors array, i.e. the pulse sensor and temperature sensor LM-35DZ has been developed, recently, by the research group at the Electrical Engineering Department, Hasanuddin University, Makassar, The constructed WBN takes the advantage of different wireless sensor networks, via a bluetooth connection, to be displayed on an Android-based smartphones. The system has been constructed in such away to allow the regular sensing and collecting the medical data then transmitted via the Arduino module device. At the computer end the data then are displayed on a smartphone apps android Pro Bluetooth SPP [10-11].

The configuration of wireless sensor network to monitor the patient health situation is illustrated in Figure 1. In practical, the array of multi-sensors to collect several critical medical parameters of the human is incorporated with the compact wireless electronic transceiver positioned in the patient body. Broadly speaking, this system consists of two devices, namely the transmitting device and the receiving device. The transmitting unit consists of a series of components microcontroller, bluetooth shield, and the array of multi medical sensors. Sensor device is a physical device that interacts directly with the patient. This device will be used to detect various medical parameters such as temperature, blood pressure rate and heart pressure. Sensor readings in the form of values of temperature and the number of beats per minute (beats per minute - BPM) will then be sent to the receiving device using bluetooth connection via a smartphone. The smartphone itself is registered to the existing wireless cellular provider which allows the long distance of communication could be established between the WBN unit installed on the patient body and the physician (or an authorized medical staff). The monitoring activity of the patient health situation could be performed, anytime and anywhere, as long as the communication using the smartphone or other modem devices to the cellular network existed.

The designed telemedicine system allows the physician (doctor) or other medical authority officers to monitor the patient health situation based on the plotted medical parameters such as blood pressure rate, temperature, heart pressure rate, and the respiration quality.

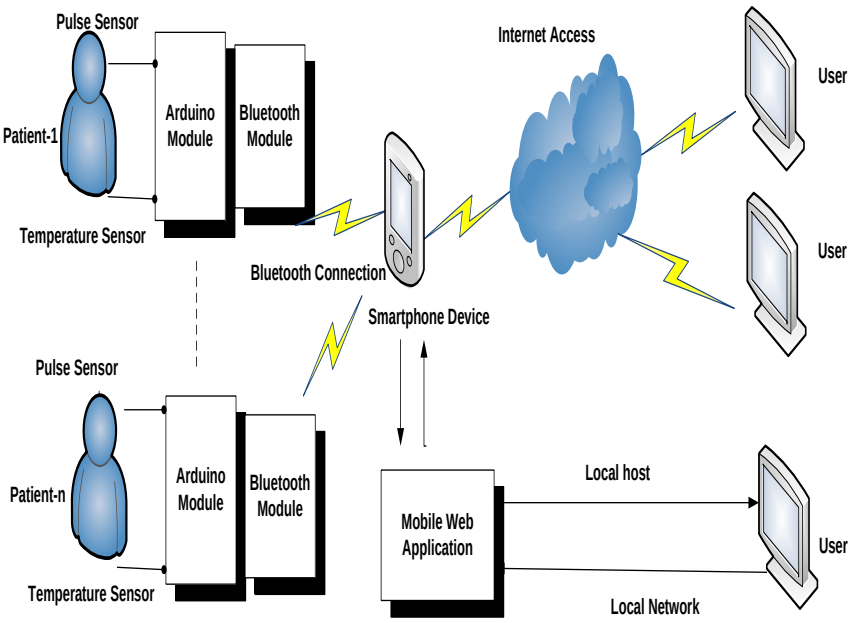


Fig. 1. The current developed WBN 2.4 GHz as a remote patient monitoring system.

The receiving device in the form of android smartphone, this device is used to receive and display the temperature data and the BPM of the subject (patient) who is sent by the sender , to display the temperature and the BPM value received by android smartphone (the receiver) is used bluetooth application protocol . Bluetooth protocol application on android smartphones also serve to store temperature data and BPM received during a certain time interval to the storage medium (internal memory) smartphone in the form of file format txt (text).

Text file containing the data of temperature and BPM has been stored in the internal memory of android smartphone then uploaded into the database on the webserver. Upload process using a web -based application that is accessed through the Internet, the web server data processing temperature and BPM to produce an average value of temperature and BPM of the patient then plotted the temperature and BPM data in graphical form as the main interface.

Temperature data and BPM that have been uploaded to the webserver can be accessed by electronic devices such as smartphones, desktop PCs, tablets, notebooks, and other devices that allow to connect to the internet. Temperature data and BPM will be displayed in graphical form as a web-based interface that is intended for doctors and other medical personnel to perform monitoring patients' health indicators (in this case the value of temperature and BPM) that can be done anytime and anywhere as long as internet is available so that the monitoring network (monitoring) remote health can be easily done.

2.1 WBN Hardware Development

As clearly shown in Figure 1 that the main element of the constructed WBN system consisted of the assembled from various electronic devices including the array of electronic medical sensors (i.e. temperature sensor LM35dz and pulse sensor), Arduino module, Bluetooth module, Breakout board, LCD16x2 display unit and other additional electronics parts. The detailed electronic connection of the implemented WBN unit is illustratively described in Figure 2. While, the actual sensors description and its corresponding pin connections are depicted in Figure 3 (a-c) as the reference to build the whole WBN unit.

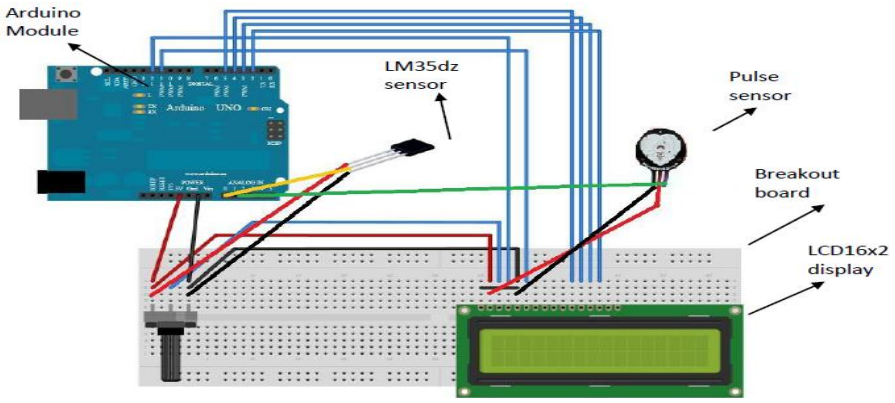
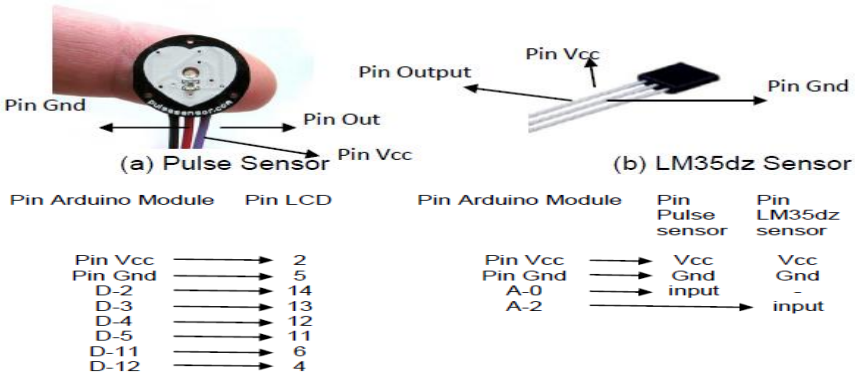


Fig. 2. The devices electrical connection to build the WBN system.



(c)

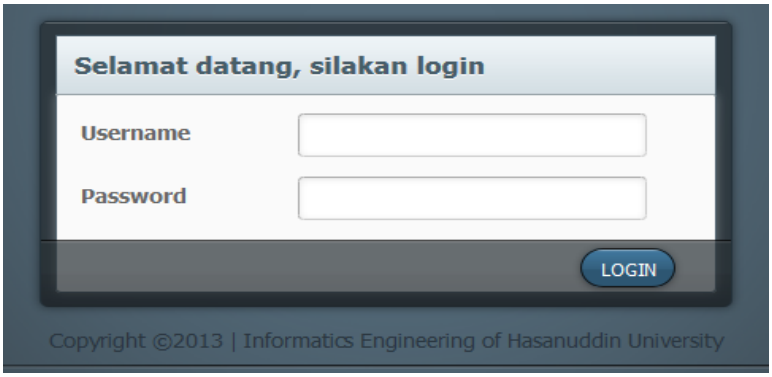
Fig. 3. The electronic sensors and their corresponding pin connection.

In actual implementation, all electronic components are interconnected in such manner to utilize the short and tiny cables on the preliminary construction and testing. As indicated in Figs. 2 and 3, the red cables are connected to the power supply + 5 Volts. Meanwhile, the black ones are grounded. The electrical voltage required for the whole constructed WBN hardware is generated from two power sources. The first one

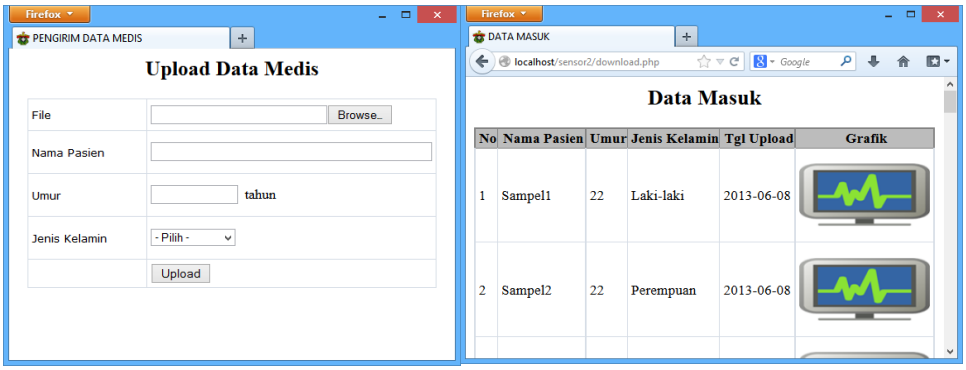
was directly fed from the Arduino module. Another power supply flows from the laptop/desktop via USB cable connector.

2.2 Multi Medical Data Display Unit

One type of a web-based technology created to be suitable to deploy in a particular field of health service system so-called UNHAS medical information system has currently developed to maintain various human health parameters capturing from the array of multisensors. The kind of telemedicine research and development activities has significant impact on the improvement of the quality of health care services to the people who geographically lived not only in the urban areas but also in the remote isolated areas. The utilization of this potential ICT innovation may open the highest possibility to perform the more practical, effective, and efficient health care services to all people. During the deployment of the designed telemedicine the big challenge might be arise on several crucial issues such as the queuing method of the patient to get a health services, the billing method (or on-line medical transactions), and the telecommunication infrastructure reliability and quality. However, those three serious matters will not be discussed in this manuscript.



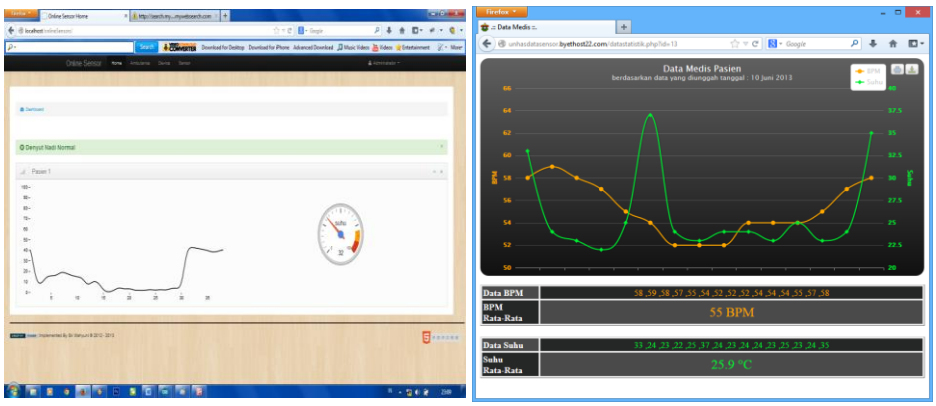
(a)



(b) (c)

Fig.4. The entry form model of the UNHAS WBN medical monitoring system

The main objectives of the current designed telemedicine system are to present the information of the patient medical data obtained from the real-time measurements using several medical sensors in the form of multi display window at the PC/laptop monitor and to plot them in the form of time-dependent graphics [12]. The approach of multi medical parameters visualization allows the doctors or paramedics to perform the best and efficient remote monitoring of the vital signs of the patient's health conditions such as heart rate, temperature, blood pulse rate, respiration and so on. This telemedicine concept may significantly alter the high consuming time of the medical diagnostic and assessment of the previous conventional methods. This information system of the designed telemedicine (WBN) is built using PHP, jQuery library, MySQL database, and Macromedia Dreamweaver CS6. The unique utility of the ICT system is to organize various data from different sensors (multisensors) and to transfer data into a dynamic and flexible database so that patient health data could be stored neatly and safely and finally plotted to the monitor. This can be used as a reference of the patient medical records for ongoing and sustainable medical treatment [10-11].



(a) (b)

Fig.5. The two different types of medical data visualization developed for UNHAS Medical IT.

A typical model of the designed medical information system is shown in Figure 4. Figure 4 (a) visualize the entry form of the patient to access the WBN system through the existing cellular network. To enter the medical IT system the users are categorized into the patient user and the physician (doctor) user. Without the proper user ID authentication a user will be restricted to explore and utilize the WBN system. By completing the form, the registered patient, under the health service officer assistance (or family member help), could update the medical history parameters to the server (see Fig. 4 (b)). The current developed medical IT system only allows the doctors or medical officers to obtain the patient information by connecting through the available provider wherever they have the chance to get connected. The type of medical parameters which can be visualized in the receiver side is classified based on the patient ID. A number of patient private information including the name, the sex, the age and the date of the uploaded data will be displayed in the form (Fig.4 (c)).

As the doctor or medical authority has successfully connected to the WBN telemedicine server and has been verified, various numbers of medical parameters could be seen graphically at the computer or laptop monitor unit. An actual visual display of the corresponding real-time collected data is depicted in Figure 5. An advanced modification and assessment regarding the data visualization techniques should be performed for many times in order to obtain the more accurate and reliable of the time dependent data visual or graphic plotted.

3 WBN Testing and Evaluations

The development of WBN system, as implicitly explained previously, consisted of two main parts, i.e. the hardware and the software aspects. To guarantee that the hardware design was constructed in a proper way therefore the research was started by studying the related physiological characteristics of the heart signals, measuring the various critical medical signals conventionally, and to analyze of how the WBN works. By studying the existing WBN, researchers can find out in detail the parts to build and this becomes a reference for designing the intended WBN to meet the required specifications [3].

There are several numbers of technical factors that influence the whole performance of the constructed WBN to be employed as the robust telemedicine system. These include the quality of the bluetooth connection between the WBN unit installed at an human body and the smartphone device, the reliability and quality of the existing telecommunication infrastructure linking a patient and a doctor, and the quality of the WBN and its corresponding software design [3]. In this paper, the bluetooth connection quality will be tested and assessed thoroughly to guarantee that the designed WBN working properly in the practical environment. The testing configuration of the whole WBN telemedicine system is shown in Figure 6.

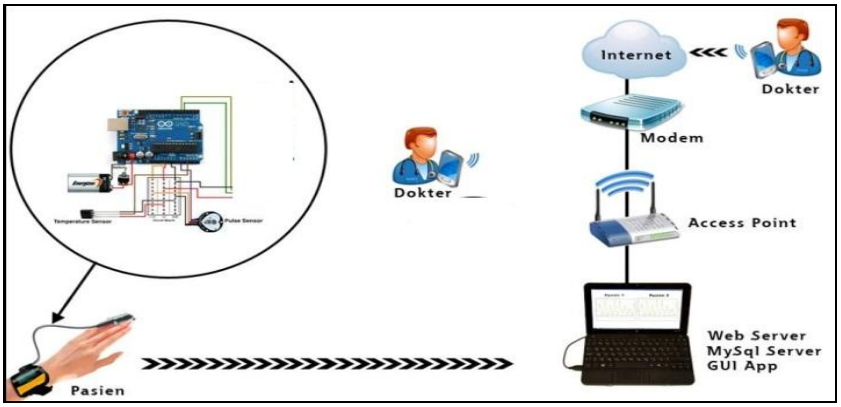


Fig. 6. The WBN set-up for the testing purpose

The read range testing of wireless BN system to perform on monitoring the heart pulses was carried out. At indoor environments it can read up to the distance of more than 50 m. When operating at LOS outdoor environment the master unit and local ECG sensor unit can communicate for the distance longer than 250 m.

Table 1. The reading range testing of the WBN bluetooth connection to smartphone.

Distance Range (meter)	Multisensor Measurements			Additional Testing Indicator
	LCD reading	PC or Laptop Monitor reading	Reading Delay (second)	
1 – 17	Read clearly	Data Received	60	Data Transmitted
>17	Read clearly	Data Error	>62	Data Transmitted

Of some test results it can be seen that, reading sensor data from Arduino module can be transmitted via a Bluetooth connection to a distance of 17 meters indoors. More than 17 meters of already existing data connection and reading the data delay stalled.

The study was conducted testing of data transmission at 60 kilobits, and it takes time to mengirimankan data via bluetooth media time required 60 seconds, then the result is obtained that is within 1-17 feet indoors takes 60 seconds to 60 kilobits of data reception. While the distance of 17 meters and above (17.5 meters) of data received by 48 kilobits, no loss of data at 12 kilobits within 70 seconds. Authors took samples of the data above or equal to 60 Mb, because that time required is calculated over 60 s, when the time required under s 60, it is difficult to calculate the time actualnya.

In picture 43, the used laptops have two (2) unit which functions as a data sender and a data receiver. Laptops are sending the data associated with multisensor device that sends data at 60 KB through the software interface SSCom then transmitted via bluetooth media while the laptop that serves as a data receiver will catch the signal bluetooth, bluetooth name "BSSlave" which then receives data via software interface SSCom, where time and distance revenues is calculated to obtain the actual values in the outcome of the actual maximum distance and throughput, and packet loss to the multisensor systems.

At the time will be measured throughput and packet loss through SSCom software, there are several parameters that need to be considered in SSCom configurations, such as: Baud rate: 9600, Data bits: 8, Stop bit: 1, Parity: No parity. From Table 8 above, it can be seen that the further the distance the more the reading of data throughput and decreases the value, the greater the value of the packet loss, which conditions the data will get a reading fails and a lot of data loss or data reading is not accurate anymore.

Table 2. The measured performance of the designed WBN based on the variations of the bluetooth connection distance.

Distance Range (meter)	Multisensor Measurements			
	Data size (Kb)	Time (Second)	Throughput (Kbps)	Packet Loss (%)
1 – 17	60,000	60	1	0
17.5	60,000	70	0.857	20 (12 Kb)
18	60,000	80	0.75	33 (20 Kb)

Various designed WBN model must be tested in various wireless environment both indoor and outdoor in order to evaluate its feasibility to apply in a particular health monitoring facilities. Some technical issues including the accuracy and safety

reasons must be studied further in the actual medical centre under the doctor evaluation and supervision.

4 Concluding Remarks

Several simple visualization techniques of the multi medical time dependant data have been developed to be incorporated with the corresponding WBNs electronic sensors applicable for various modern e-Health technologies. The adopted data visualizations approaches allow a doctor (or physician/authority medical staff) to maintain the patient health data obtained from several patients through each running medical data plotted on various windows of a computer monitor. The recent WBNs designs have significant impacts on the improvement of people health situation especially the health quality of the rural communities. The advanced development of the interactive telemedicine system with its corresponding intelligent database unit allows a better health services, potential technology innovation to solve the limited medical staff availability and the poor quality and the limited quantity of health centre resources.

Various topology of WBN Telemedicine could be reconstructed, depending on the type of applications intended and the target end users.

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